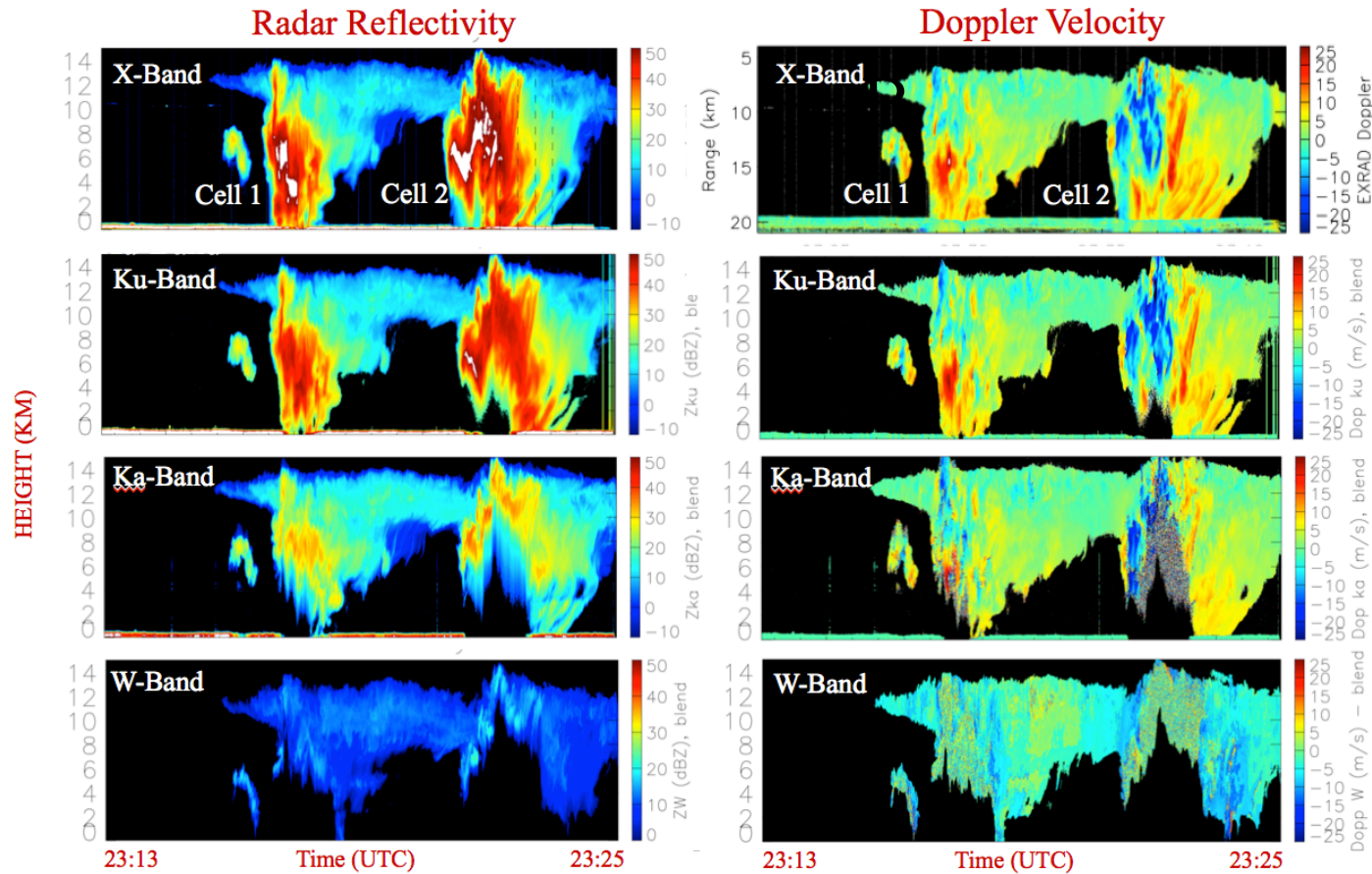




Four-Frequency Radar Measurements of Clouds and Precipitation From NASA ER-2

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- Three radars installed on the NASA ER-2 high-altitude aircraft (HIWRAP, CRS, EXRAD) provides the first 4-frequency reflectivity and Doppler measurements from precipitation and clouds.
- Two severe storms on 5/23/2014 observed during the GPM Ground Validation (GV) Integrated Precipitation and Hydrology Experiment (IPHEX).
- The 4 frequencies permit measurements with a broader detection of clouds and precipitation for the multi-frequency microphysical retrievals that are used in GPM and are planned for future missions such as ACE Decadal Mission.



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Heymsfield, G. M., L. Tian, L. Li, M. McLinden, and J. I. Cervantes, 2013: Airborne Radar Observations of Severe Hailstorms: Implications for Future Spaceborne Radar. *Journal Applied Meteorology and Climatology*, **52**, 1851–1867. doi: <http://dx.doi.org/10.1175/JAMC-D-12-0144.1>

Acknowledgements: The HIWRAP, CRS, and EXRAD radars have been developed at Goddard Space Flight Center jointly between the Mesoscale Atmospheric Processes Laboratory (612) and the Microwave Instrument Technology Branch (555). Key engineers involved in the development of these radars are Lihua Li, Matthew McLinden, Michael Coon, and Martin Perrine. This work was funded by the Global Precipitation Mission (GPM) ground validation, Aerosol Clouds and Ecosystem (ACE) Decadal Survey algorithm formulation, and NASA PMM. ACE funded the Radar Experiment (RADEX) portion of IPHEX that contributed CRS participation to the campaign. HIWRAP was developed under the 2004 NASA ESTO IIP. EXRAD was funded under a 2013 NASA AITT for installation on the ER-2. CRS used an ACE sub-scale antenna that was developed under a 2012 NASA IIP.

Data Sources: IPHEX <http://har.gsfc.nasa.gov/index.php?section=55>

Technical Description:

Three Goddard radars:

- High-altitude Imaging Wind and Rain Airborne Profiler (HIWRAP), Cloud Radar System (CRS), and ER-2 X-band Radar (EXRAD).
- HIWRAP has flown on both the Global Hawk during the Hurricane Severe Storm Sentinel (HS3) and in was installed in a non-scanning mode on the NASA ER-2. HIWRAP is Ku-band (13.5 GHz) and Ka-band (35.5 GHz).
- CRS is a completely new radar with a solid state transmitter; the original CRS was tube-based built in 1992. It is the first cloud radar utilizing a low power solid state power amplifier (SSPA) with pulse compression. The ACE radar concept calls for a Ka- and W-band Doppler radar and this is simulated with the HIWRAP Ka-band radar and CRS.
- EXRAD was originally developed for the Global Hawk about 2004 and was then installed on the ER-2. At 9.6 GHz, this radar has significantly better penetration into severe weather compared to Ku and shorter wavelengths. EXRAD has a fixed nadir beam and a cross-track or conical scanning beam. The latter is used for horizontal wind measurements.

Figure Caption: Radar reflectivity and Doppler velocity corrected for aircraft motions are shown for the four frequencies for two hail storms on 23 May 2014 in northern SC during the Integrated Precipitation and Hydrology Experiment (IPHEX) sponsored by GPM. These storms produced large hail (>2 inches) and had updrafts exceeding 25 ms^{-1} (seen by the deep blue colors in the Doppler plot). Strong attenuation and Mie scattering occur in the convective cores at the shorter wavelengths. Cross sections such as these are being analyzed along with ER-2 radiometric measurements will provide both a better understanding convective storms and improvement in physics assumptions in satellite retrieval algorithms.

Scientific significance, societal relevance, and relationships to future missions: The three radars providing X- through W-band provide a both a simulator for future missions, and additional and higher resolution measurements for current missions such as GPM and CloudSat. This combination of instruments provides the first dual-frequency Ka & W-band measurements for development of retrieval algorithms for ACE. It provides GPM-like measurements at Ku and Ka-band that along with W-band, can be used to improve the physics in the GPM algorithms and to study significant data issues in current and future missions such as non-uniform beam filling.

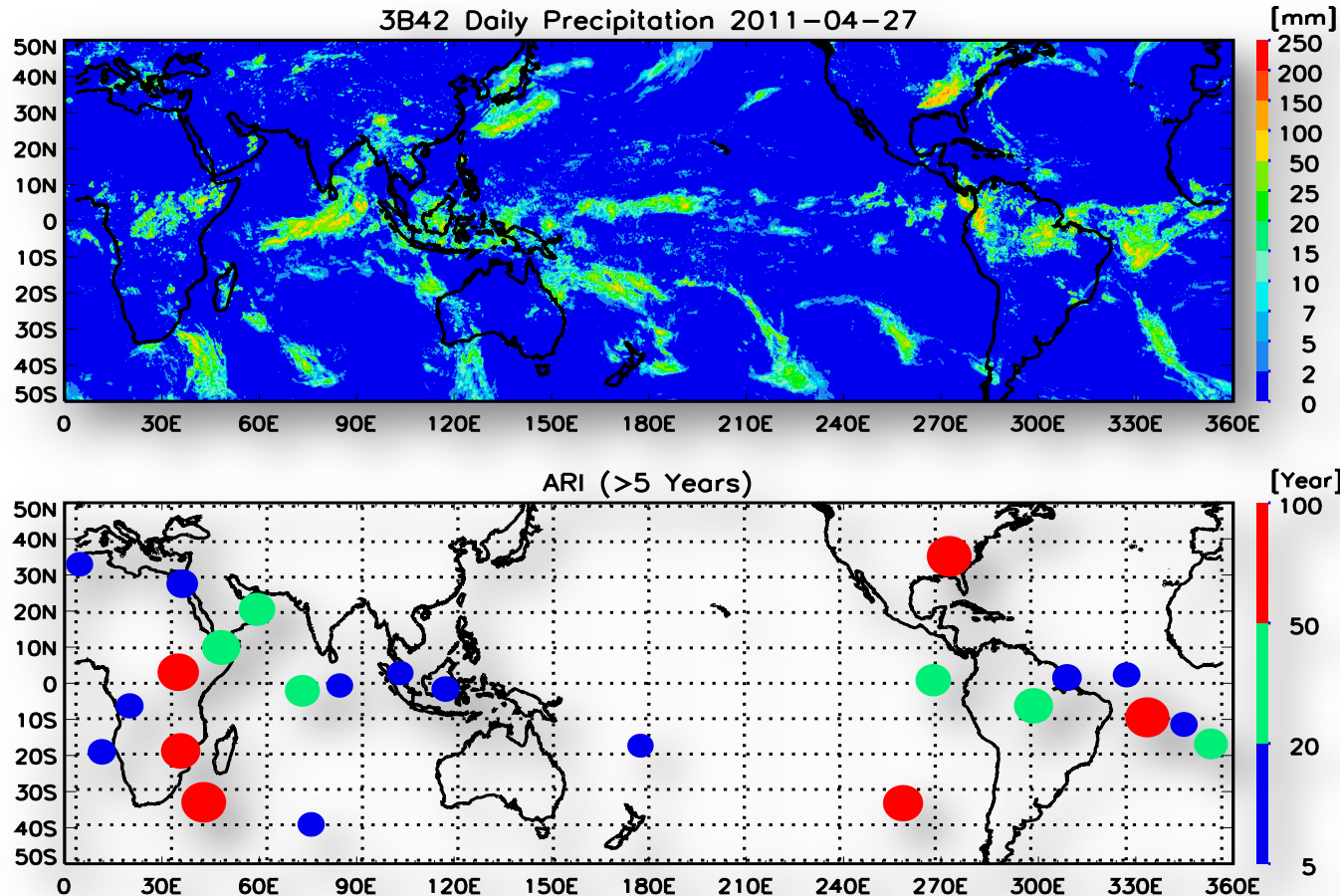


TRMM Extreme Precipitation Monitoring System

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MORGAN
STATE UNIVERSITY



The TRMM Extreme Precipitation Monitoring System (ExPreS) shows precipitation accumulation and corresponding Average Recurrence Interval (ARI) or Return-Year for the past 1~10 days computed from near-real-time TRMM Multi-satellite Precipitation Analysis (TMPA). The areas with severe extreme precipitation are indicated with colored dots. The system is intended to raise awareness of potential hazards and support disaster management.



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Reference:

Zhou, Y., K. -M. Lau, and G. Huffman (2015), Mapping TRMM TMPA into average recurrence interval for monitoring extreme precipitation events, *Journal of Applied Meteorology and Climatology*, 54 (5): 979-995, doi:10.1175/JAMC-D-14-0269.1.

http://trmm.gsfc.nasa.gov/publications_dir/ari_slide_show.html

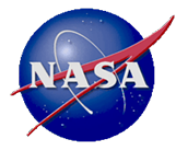
Data Sources: TRMM 3B42RT is the main input data for the monitoring system. Gauge-based daily unified precipitation data used for validation come from NOAA's Climate Prediction Center (CPC) and from the Asian Precipitation - Highly-Resolved Observational Data Integration Towards Evaluation of Water Resources (APHRODITE) project.

Technical Description of Figures:

The **TRMM extreme precipitation monitoring system (ExPreS)** computes local extreme statistics and lookup tables mapping the precipitation amount with Average Recurrence Interval (ARI) using retrospective 3B42RT data based on Generalized Extreme Value (GEV) distribution functions. The real-time (RT) 3B42RT data is converted to ARI as soon as it becomes available to provide warnings on potential hazards.

The figure shows a sample web display showing the 1-day precipitation accumulation (**top panel**) and the accompanying clickable ARI map (**bottom panel**) on April 27, 2011. The ARI map highlights the areas with locally rare extreme precipitation accumulations that could lead to potential hazards, especially over land. The big red dot in the southeastern US captures the heaviest rain episode with ARI > 50 years during the April - May period in 2011, when a series of heavy rain episodes led to massive lower Mississippi River floods - one of the largest and most damaging floods recorded along this U.S. waterway in the past century.

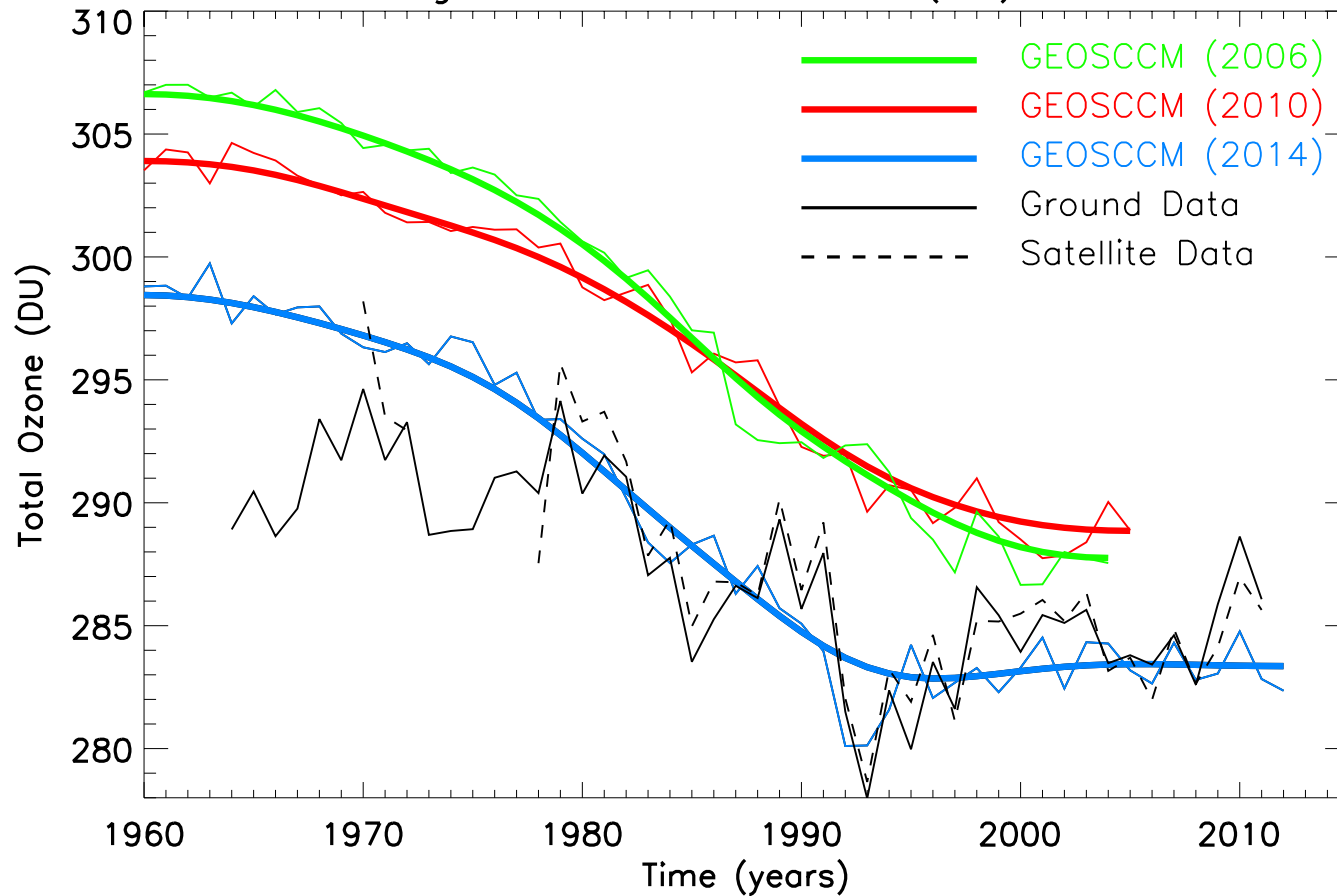
Scientific significance, societal relevance, and relationships to future missions: The TRMM Extreme Precipitation Monitoring System converts TRMM data into easily understood ARI warning system for potential rain-triggered hazards. It facilitates the use of NASA's science and technology for the direct benefit of US and global disaster monitoring communities as well as the general public. The system will be further improved with better statistics and with upcoming high-resolution GPM IMERG data.



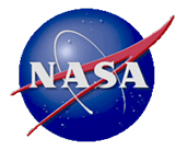
Improvements in the Simulation of Ozone in GEOSCCM

Luke Oman and Anne Douglass, Code 614, NASA/GSFC

Annual Avg. Total Column Ozone (DU) 60°S–60°N



The Goddard Earth Observing System Chemistry-Climate Model (GEOSCCM) was featured prominently in the most recent 2014 World Meteorological Organization's (WMO) quadrennial Scientific Assessment of Ozone Depletion. Due to continued model development, the 2014 ozone simulation compares better with satellite and ground-based observations than prior simulations that were contributed to WMO 2006 and 2010 reports.



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References:

Oman, L. D., and A. R. Douglass, 2014: Improvements in Total Column Ozone in GEOSCCM and Comparisons with a New Ozone Depleting Substances Scenario, *Journal of Geophysical Research: Atmospheres*, 119, 5613-5624, doi:10.1002/2014JD021590.

World Meteorological Organization (WMO), Scientific Assessment of Ozone Depletion: 2014, World Meteorological Organization, Global Ozone Research and Monitoring Project—Report No. 55, 416 pp., Geneva, Switzerland, 2014.

Data Sources:

The satellite observations are from NASA's Total and Profile Merged Ozone Data Set version 8.6 [Bhartia *et al.*, 2013] (http://acbd-ext.gsfc.nasa.gov/Data_services/merged/index.html) compiled from a series of NASA and NOAA satellites since 1970. The ground-based total column ozone (TCO) measurements, which are updated from Fioletov *et al.* [2008], go back to 1964.

Bhartia, P. K., R. D. McPeters, L. E. Flynn, S. Taylor, N. A. Kramarova, S. Frith, B. Fisher, and M. DeLand (2013), Solar backscatter UV (SBUV) total ozone and profile algorithm, *Atmospheric Measurement Techniques*, 6, 2533–2548, doi:10.5194/amt-6-2533-2013.

Fioletov, V. E., *et al.* (2008), The performance of the ground-based total ozone network assessed using satellite data, *Journal of Geophysical Research*, 113, D14313, doi:10.1029/2008JD009809.

Technical Description of Figure:

The evolution of quasi-global (60°S-60°N) total column ozone (DU) simulated in different versions of the Goddard Earth Observing System Chemistry-Climate Model (GEOSCCM) is shown compared to observed satellite and ground-based measurements. Different versions of GEOSCCM are labeled 2006, 2010 and 2014 and represent the contributions to the World Meteorological Organization's (WMO) quadrennial Scientific Assessment of Ozone Depletion reports. Continued model development, including: an internally generated quasi-biennial oscillation, impacts of volcanic eruptions, very short lived bromine sources, and a better representation of photochemistry at high solar zenith angles, has resulted in a significantly improved simulation of ozone compared to satellite and ground-based data.

Scientific significance, societal relevance, and relationships to future missions: GEOSCCM played an important role in the World Meteorological Organization's (WMO) quadrennial Scientific Assessment of Ozone Depletion (2006, 2010, and 2014) reports, with not only in understanding past changes in ozone but also helping to understand and project changes over the 21st century. Data from operational SBUV/2 instruments is being used to continue this long climate record of total column ozone from satellites like Suomi National Polar-orbiting Partnership (NPP). Future missions such as Joint Polar Satellite System (JPSS) are the next generation of satellites carrying ozone sensors that can continue this critical record well into the future.